

CLAIMS:

1. A switchable optical element comprising: a fluid chamber (2) including first and second bodies of fluid (20, 22) disposed relative to one another along an optical axis of the switchable optical element, a first electrode (24) coupled to the first body of fluid (20), and a second electrode (26), wherein the second body of fluid (22) is arranged to move
5 substantially transverse to the optical axis in response to a voltage applied to the first and second electrodes (24, 26) and thereby change the transmissivity of the fluid chamber (2) along the optical axis.
2. The switchable optical element of claim 1, wherein the second fluid (22) is a
10 non-conducting liquid, and the first fluid (20) is at least one of a polar liquid and a conducting liquid.
3. The switchable optical element of claim 1 or 2, further comprising a first
15 contact layer (28) forming an insulating barrier between the second electrode (26) and the first and second bodies of fluid (20, 22) within the fluid chamber (2).
4. The switchable optical element of claim 3, wherein the first contact layer (28)
20 comprises a material with a higher wettability with respect to the second fluid (22) than with respect to the first fluid (20).
5. The switchable optical element of claim 3 or 4, wherein the first contact layer
(28) comprises an amorphous fluoropolymer.
6. The switchable optical element of any one of the above claims, wherein the
25 first contact layer (28) comprises a first area having a first wettability by the first fluid (20), and a second area having a second, higher wettability by the first fluid (20).
7. The switchable optical element of any one of the above claims, wherein the
movement of the second body of fluid (22) is caused by an electro-wetting effect.

8. The switchable optical element of claim 7, wherein the first contact layer (28) comprises an area at which the separation of the second electrode (26) from the first and second bodies of fluid (20, 22) is reduced to locally increase the electro-wetting effect.

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9. The switchable optical element of claim 7 or 8, wherein the first contact layer (28) comprises an area which protrudes into the fluid chamber (2) to locally increase the electro-wetting effect.

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10. The switchable optical element of any one of claims 7 to 9, wherein the interior surfaces of the fluid chamber(2) comprise an inhomogeneity arranged to increase the reproducibility of motion of the second body of fluid (22) in response to a voltage applied to the first and second electrodes (24, 26).

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11. The switchable optical element of any one of claims 7 to 10 as dependent on claim 6, wherein the area of increased wettability is provided on the optical axis of the switchable optical element.

12. The switchable optical element of any one of the above claims, wherein the

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second electrode (26) comprises a plurality of independently addressable sections.

13. The switchable optical element of claim 12 wherein the independently addressable sections are arranged to provide different wettabilities across the first contact layer (28) in response to a range of applied voltages.

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14. The switchable optical element of any one of the above claims, wherein the second electrode (26) is transparent and arranged substantially transverse to the optical axis

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15. The switchable optical element of any one of the above claims further comprising: a third body of fluid (23) within the fluid chamber (2) disposed relative to the first and second bodies of fluid (20,22) along the optical axis of the switchable optical element, and a third electrode (26'), wherein the third body of fluid (23) is arranged to move in a direction substantially transverse to the optical axis in response to a voltage applied to

the first and third electrodes (24, 26') and thereby change the transmissivity of the fluid chamber (2) along the optical axis.

16. The switchable optical element of claim 15, further comprising a second
5 contact layer (28') forming an insulating barrier between the third electrode (26') and the bodies of fluid within the fluid chamber.

17. The switchable optical element of claims 15 or 16, wherein the third body of fluid (23) has a different transmissivity spectrum to the second body of fluid (22).

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18. The switchable optical element of any one of claims 15, 16 or 17, wherein the interior surfaces of the fluid chamber (2) in contact with the first body of fluid when no voltage is applied to the switchable optical element are of higher wettability by the first fluid (20) than by the second fluid (22).

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19. The switchable optical element of any preceding claim, wherein all of said fluids are of substantially equal density.

20. The switchable optical element of any preceding claim, wherein the switchable optical element is at least one of a shutter, a diaphragm, a diffuse reflector or a filter.

21. An optical device comprising a switchable optical element, wherein the switchable optical element comprises a fluid chamber (2) including first and second bodies of fluid (20, 22) disposed relative to one another along an optical axis of the switchable optical
25 element, a first electrode (24) coupled to the first body of fluid (20), and a second electrode (26), wherein the second body of fluid (22) is arranged to move substantially transverse to the optical axis in response to a voltage applied to the first and second electrodes (24, 26) and thereby change the transmissivity of the fluid chamber (2) along the optical axis.

30 22. The optical device of claim 21, further comprising at least a further switchable optical element according to any one of claims 1 to 20, where the switchable optical elements are configured in series or parallel to provide switchable transmission characteristic for the optical device.

23. The optical device of claim 21 or claim 22 further comprising a lens.

24. The optical device of claim 23 wherein the lens is formed integrally with the switchable optical element.

5 25. The optical device of claim 23 or 24 wherein the lens is an adjustable electrowetting lens.

10 26. The optical device of any one of claims 21 to 25, wherein the optical device comprises a device (61) for scanning an information layer (64) of an optical record carrier (62), comprising a first radiation source (611) for generating a first radiation beam (612) and an objective system (618) for converging the first radiation beam (612) on the information layer (64), and the switchable optical element is arranged to control the first radiation beam (612).

15 27. The optical scanning device of claim 26 further comprising a second radiation source for generating a second radiation beam of different wavelength to the first radiation beam, wherein the objective system (618) is selectively arranged to converge the first or second radiation beam on the information layer, and the switchable optical element is further
20 arranged to control the second radiation beam.

28. The optical scanning device of claim 26 or 27, wherein the switchable optical element is incorporated into the objective system (618).

25 29. A method of manufacturing a switchable optical element, the method comprising the steps of: providing a fluid chamber (2) including first and second bodies of fluid (20, 22) disposed relative to one another along an optical axis of the switchable optical element; and providing a first electrode (24) coupled to the first body of fluid (20), and a second electrode (26), wherein the second body of fluid (22) is arranged to move
30 substantially transverse to optical axis in response to a voltage applied to the first and second electrodes (24, 26) and thereby change the transmissivity of the fluid chamber (2) along the optical axis

30. A method of manufacturing an optical scanning device (61) for scanning an information layer (64) of an optical record carrier (62), the method comprising the steps of: providing a first radiation source (611) for generating a first radiation beam (612); providing an objective system (618) for converging the first radiation beam (612) on the information layer (64); and providing a switchable optical element arranged (600) to control the first radiation beam (612), the method characterised in that the switchable optical element (600) provided comprises: a fluid chamber (2) including first and second bodies (20, 22) of fluid disposed relative to one another along an optical axis of the switchable optical element (600), a first electrode (24) coupled to the first body of fluid (20), and a second electrode (26), wherein the second body of fluid (22) is arranged to move substantially transverse to the optical axis in response to a voltage applied to the first and second electrodes (24, 26) and thereby change the transmissivity of the fluid chamber (2) along the optical axis.